Space Weather Technical Forecast

Issued on Thursday, 30 December 2021 at 13:28 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Slight chance of G1/Minor storm, mainly on Day 3.

Analysis of Space Weather Activity over past 24 hours
Solar Activity: Solar activity was low, with no C-class flares observed in the last 24 hours. There are five sunspot regions on the visible disc, with the mature region AR2916 (Eki/beta) the largest and presenting the largest flare potential. The remaining regions are either weak or fading. A CME appears to have left the northwest limb late on 29 December, and this will be analysed once further data becomes available.

Solar Wind / Geomagnetic Activity: The solar wind speed as observed at L1 started between 300-400km/s, but then increased to 474km/s at 30/0107UTC before declining to a steady speed of 410km/s. A second peak of 517km/s was observed at 30/1237UTC. Density was generally around average but rose above average between 29/2043UTC and 30/0036UTC, reaching a peak of 33ppcc at 30/0010UTC, before returning to average levels. Total magnetic field strength started weak but was moderate from 29/2043UTC until 30/0829UTC and was strong between 29/2217UTC and 30/0109UTC, with a peak of 21nT at 30/0035UTC. The north-south component, Bz, varied generally weakly, but reached a positive peak of 18nT at 30/0040UTC and a negative peak of -11nT at 30/0109UTC. These observations suggest that the first peak was the glancing CME and the second was the high speed stream, but the data will need to be analysed further. Phi angle was predominantly positive (away from the Sun) but became negative between 30/0400UTC and 30/0600UTC, and then from 30/100UTC. Geomagnetic activity has been Quiet throughout.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) remained at background levels. The high energy electron flux (greater than 2 MeV) started at moderate levels, but has since fallen to background. Electron fluence values have been below the Active threshold (1e8 integrated pfu) throughout.

Four-Day Space Weather Forecast Summary
Solar Activity: Low or very low solar activity is expected through the next four days, with a slight chance of moderate activity due to AR2916 in the southwest quadrant.

Solar Wind / Geomagnetic Activity: Earth may experience a glancing blow from a CME on 30 December, although there is limited evidence to suggest that it may have already affected the Earth. A current high speed stream from coronal hole 39 is expected decline by day 2, with a further high speed stream from coronal hole 40 then likely to connect on day 3 (01 January), which may produce speeds of around 500km/s. Geomagnetic activity is expected to be mainly Quiet, with a slight chance of Active or G1/Minor Storms due to either the effects of the CME on 30 December or the connection with the second fast wind on 01 January.

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Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at background levels, albeit with a very slight chance of S1 should there be any significant flare activity. High energy electron flux levels are expected to reach moderate levels through the period, although given the relatively modest high speed stream high (1e3pfu) levels are considered unlikely. Electron fluence is expected to remain below the Active (1e8 integrated pfu) threshold.

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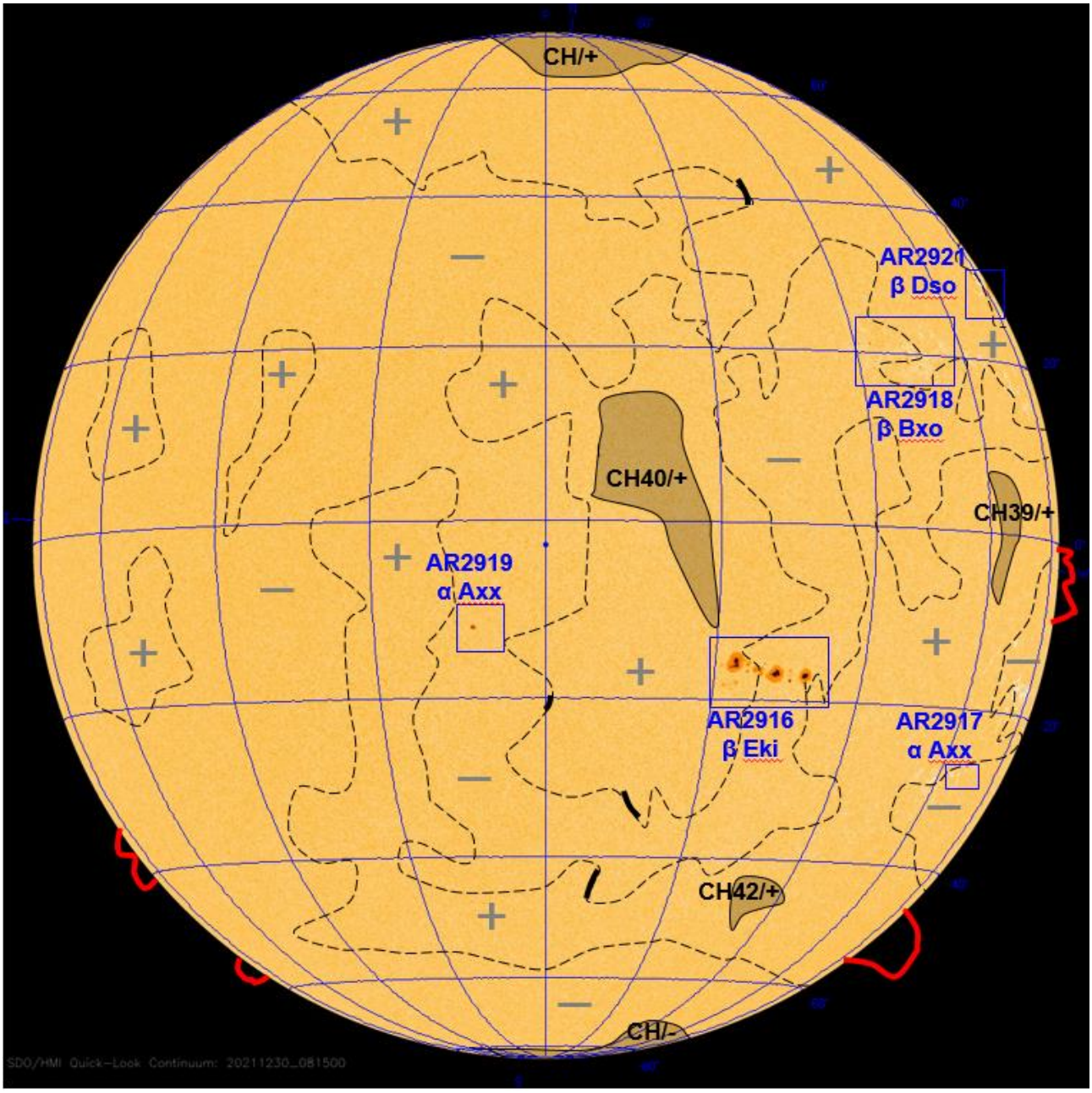
Figure 1. Solar Analysis Valid 30/0800UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A CME which left the Sun on 26 December may have glanced the Earth, but evidence is inconclusive. If the CME is still due, then the impacts are expected to be minor, although the timing is low confidence, with a chance that the feature may miss the Earth entirely.

The high speed stream from coronal hole 39 is currently connected with the Earth, giving observed speeds of around 500km/s. This is expected to continue through the next two days (30 and 31 December) as the coronal hole moves towards the western limb. Coronal hole 40, which is a recurrent feature, is then forecast to connect with the Earth on 01 January, and is likely to give speeds in the region of 500km/s through to the end of the period.

Geomagnetic activity is expected to be Quiet to Unsettled through days 1 and 2 (30 and 31 December), although Active or G1/Minor storm intervals are possible in the presence of any CME effects. Generally Quiet with isolated Unsettled or Active intervals are possible on days 3 and 4 due to the high speed stream from coronal hole 40, although there is a small chance of G1/Minor Storms.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	10	5	10	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
27/0418	N/A	Filament eruption	SW quadrant	500km/s	30/1200UTC	Limited glancing blow

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Figure 2: Observations at L1 from DSCOVR and ACE, the large increase in density and the two increases in solar wind velocity are clearly visible.

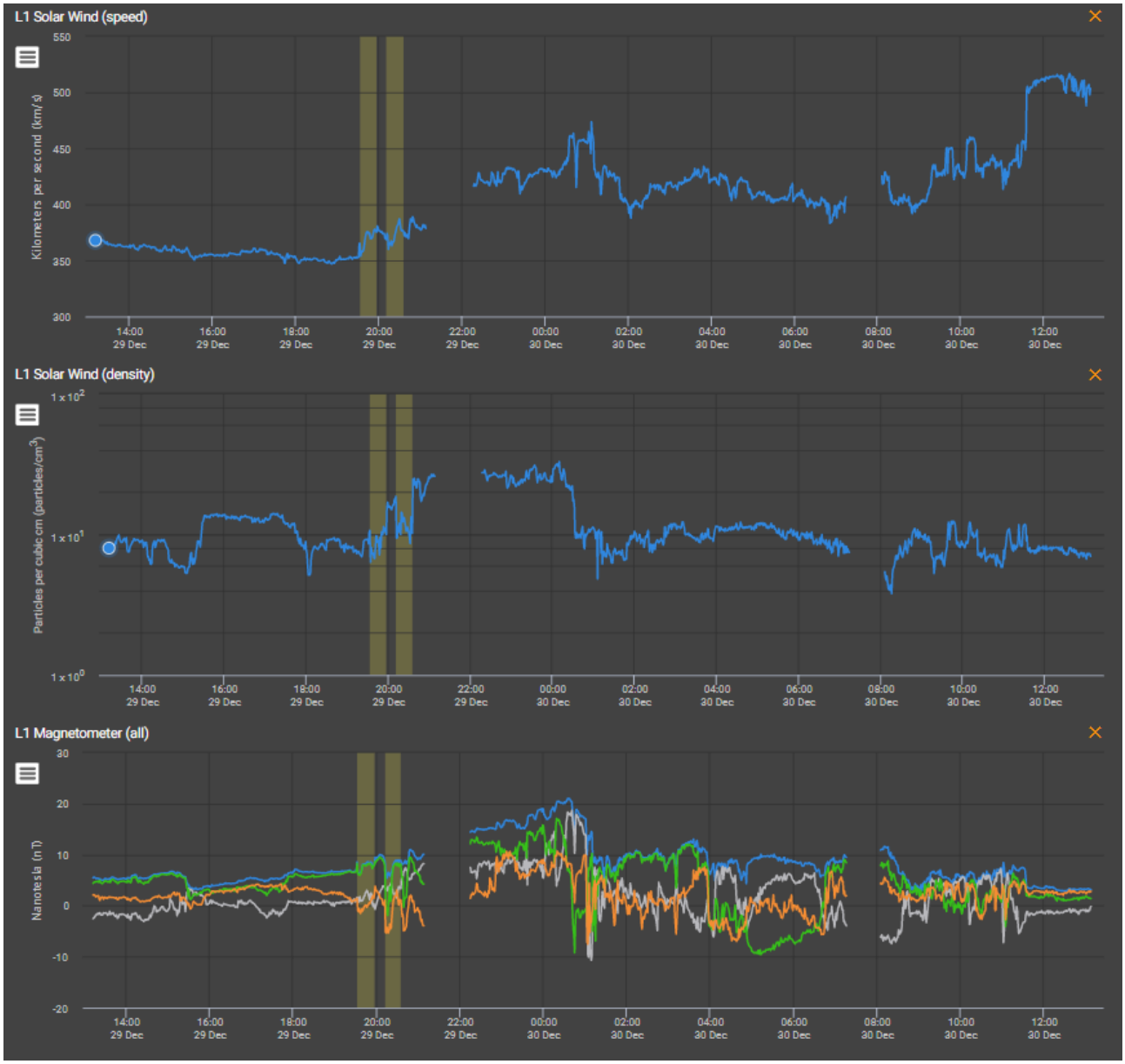

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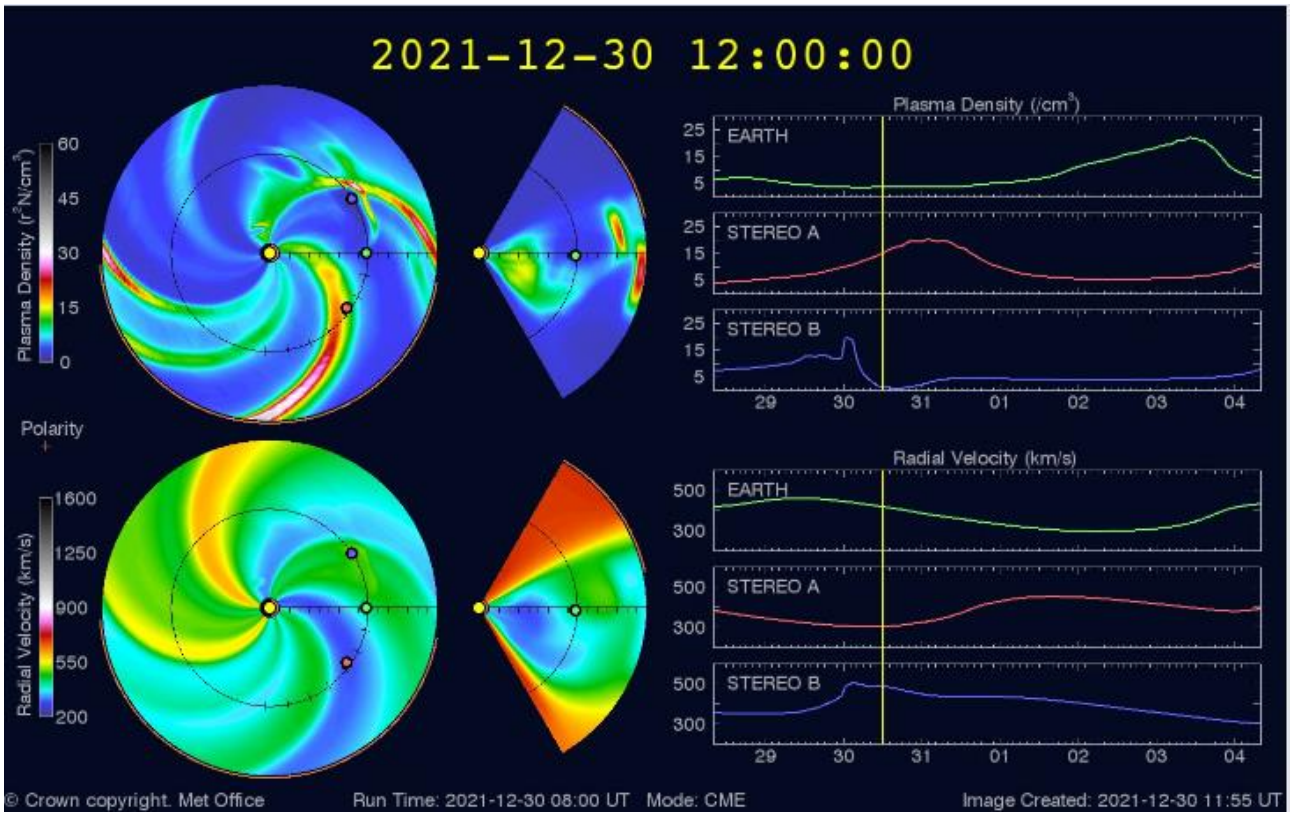
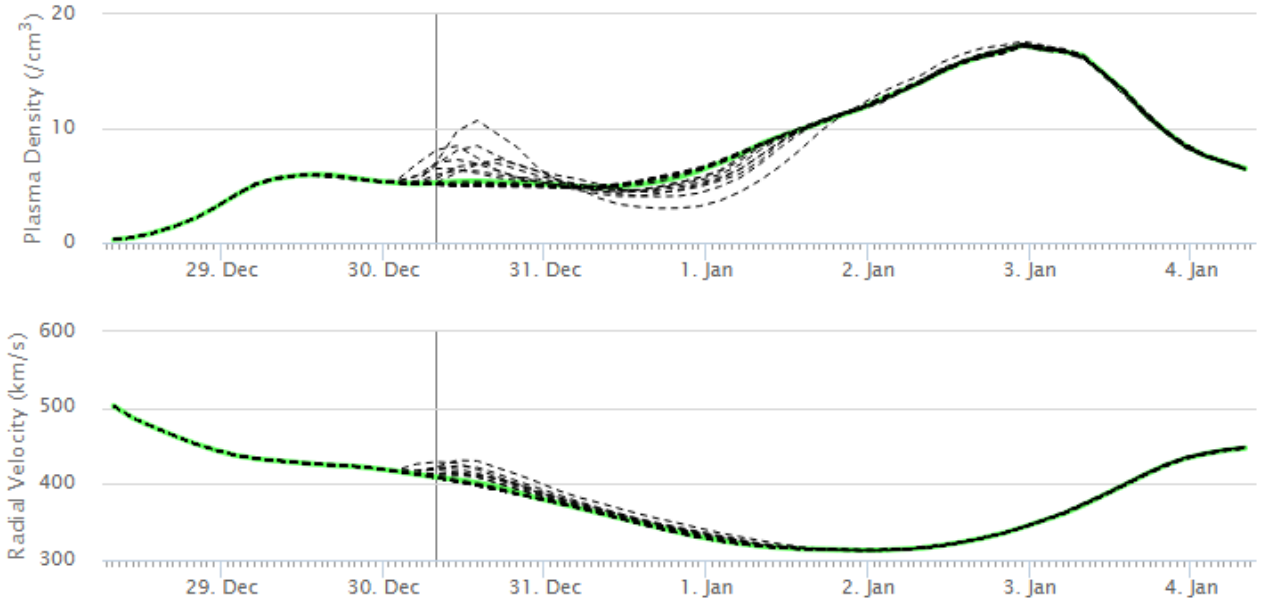
Figure 3: MOSWOC Enlil showing time of possible CME arrival (see text for discussion on this) and MOSWOC Enlil ensemble, demonstrating uncertainty in any arrival time.





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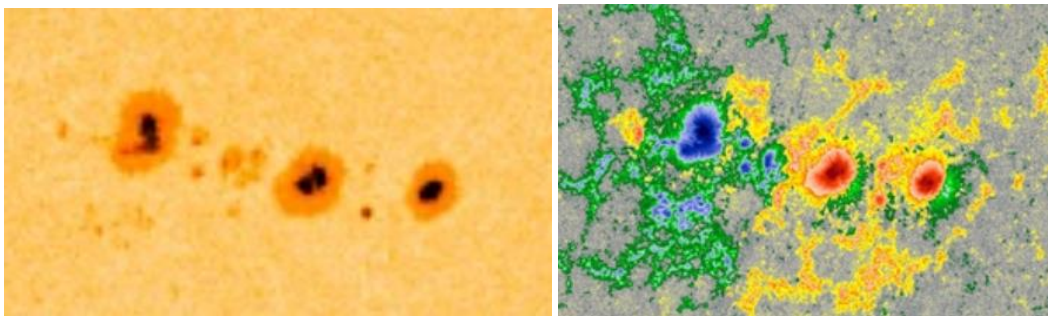
Radio Blackouts - X-Ray Flares:
Solar activity is expected to be mainly low or very low through the next four days, with all the active regions either stable or decaying. The main contribution to any risk of M-class flares is from 2916 (Eki/Beta) which is a mature region in the southwest quadrant, although this has not flared significantly over the last 24 hours. This region is due to remain on the disc through the next four days, maintaining a low risk of moderate solar activity.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	15	15	15	15
Very Active	R3 to R5 X Class	No	5	3	1	1

Figure 4: SDO HMI intensitygram and magnetogram imagery of AR2916 in the southwest quadrant



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Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) as observed by GOES-16 is currently at background levels and will most likely persist as such. There is a very slight chance of S1 from any notable flares on the disc, probably most likely from AR2916 as it rotates across the western hemisphere.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	3	3	3
Very Active	**≥ S3 ***	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

High Energy Electrons Event (≥ 2MeV):

High energy (greater than 2MeV) electron flux levels are at background and are likely to stay at these levels through day 1 and into day 2, due recent reductions due to the onset of the high speed stream from coronal hole 39. Some limited recovery in these levels are expected on day 2 due to the modest high speed stream, but this is subject to the potential CME arrival, should it still be due. A further pattern of reduction and limited recovery is then likely on days 3 and 4 as the high speed stream from coronal hole 40 connects with the Earth.

Electron fluence may rise as a result of the two high speed streams, but with the forecast geomagnetic enhancements, any increase should remain below the Active threshold.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	10	10	10	10
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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